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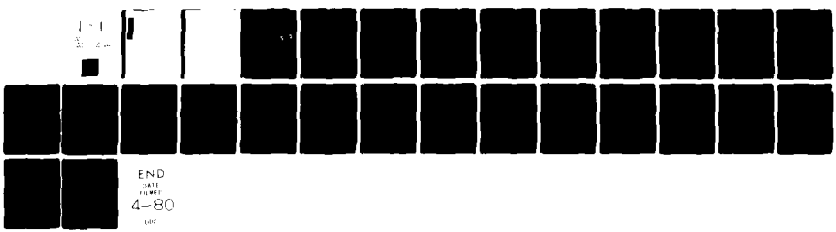

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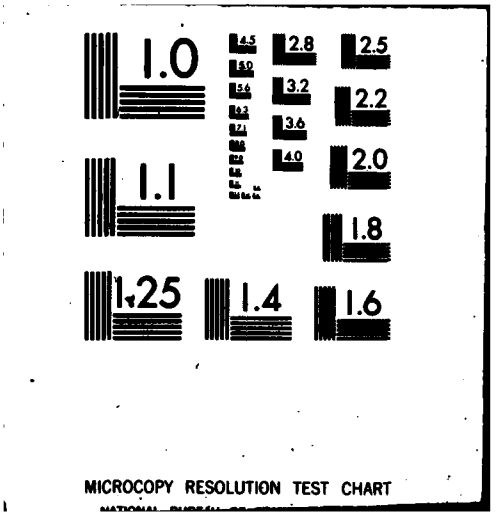
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5.0
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6.3
7.1
MICROCOPY RESOLUTION TEST CHART

12

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

GEODSS ORBIT DISPLAY PROGRAM (GEOD)

A. J. WARDROP

Group 94

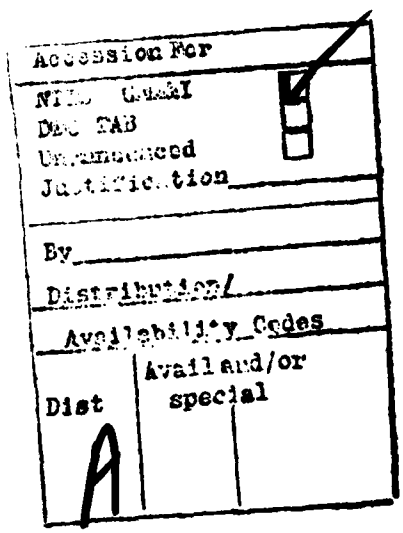
PROJECT REPORT ETS-48

19 NOVEMBER 1979

LEXINGTON MASSACHUSETTS

ABSTRACT

An interactive computer program has been developed for plotting world maps, satellite ground tracks, and orbit coverage by a system of ground sensors. All plotting is done by an HP7221A four color pen plotter attached to the Modcomp IV. This report is a users manual for this program, and contains several examples of plots.



CONTENTS

I. INTRODUCTION

The GEODSS Orbit Display (GEOD) is an interactive computer task which allows the user to plot world maps, satellite ground tracks, and orbit coverage by a system of ground sensors. All plotting is done by an HP7221A four color pen plotter attached to the Modcomp IV at Lexington. The program accesses the same satellite files and ephemeris routines used for all ETS operations.

All positions to be plotted are expressed in latitude and east longitude. A subroutine then provides the proper transformation to x, y plotter coordinates for the map projection chosen. Four map projections are currently available, and more can be easily added.

An internal list of 27 sites is provided, and more can be added. Each site can be "ACTIVE" or not. When a satellite ground track is plotted it can be indicated at each plotted point from which active sites it can be seen. Visibility is indicated by drawing a line from the sensor position to the satellite ground trace. The line may be solid, dashed in various formats, or blank to indicate daytime or nightime passes or if the satellite is in the shadow of the earth. Sensor coverage circles for constant altitude orbits can be plotted.

II. OPERATION

The program is activated from the computer operator's console by typing:

/GEOD/ACT,,TM

It erases the CRT screen at the user's terminal, writes its name, version ID and the current day/date/time on the screen, writes a prompting question mark and awaits user input.

In addition, the continental shoreline data tape, CONDIG2, must be mounted on a tape drive and file 7 assigned to that drive. This is done by typing:

/GEOD/ASS 7 MTx

on the operator's console, where x is 1 or 2, depending on the tape drive used.

III. COMMAND STRUCTURE

GEOD is command structured with free format input. All commands may be abbreviated by their first three characters. Characters after the third are ignored. Sixteen commands are available. For most commands the arguments may either be typed on the same line as the command or entered separately.

The form of a typical command line is:

COM argl,...,argn

As noted above, the command field "COM" in this example, must be at least three characters long. The arguments may be separated by a comma, an equal sign, a slash, or one or more spaces. A space cannot be used in conjunction with any of the other separators because the system interprets this as a null (zero) argument. Table 1 tabulates the comments and gives a synopsis of their use.

TABLE I

COMMANDS OF GEOD

SET UP	PLOTTING	DESCRIPTION
SET		Set or list various parameters
TIMe		Set time of interest
SATellite		Obtain satellite element set from master file
OLD		Obtain old element set
NEW		Enter element set from console
SITe		List or enter sensor positions
ACTivate		Place sensor site on the active list, or list active sites
DEActivate		Remove site from active list
	MAP	Initialize plotter, draw world map
	PLOt	Plot sensor sites and coverage circles
	PASs	Plot satellite ground trace
	COVerage	Plot satellite ground trace and sensor coverage
	PEN	Select new plotter pen
	POInt	Plot satellite ground trace and sensor coverage
EXIt		Terminate program

IV. COMMANDS

1. SET <PARM<, VALUE>>

The SET command allows various parameters of the calculations to be listed or modified. If SET is used with no parameters, a list of parameters available for modification will be printed.

If SET is used with only a parameter name, the current setting of that parameter will be printed.

If SET is used with both a parameter name and a value, the parameter will be set to that value. All parameters have default values when the program is initialized.

Floating Point Parameters For SET Command And Default Values:

HT 0.0 KMS

Height above geoid used for plotting coverage circles of constant altitude orbits. See PLOT command.

HOR 20.0 Degrees

Sensor minimum elevation angle. Used for determining satellite visibility in the COVERAGE and PLOT commands.

STEP * Minutes

Time interval for calculating satellite positions. If not explicitly set it defaults to 1/72 of the orbital period of the first satellite to use PASS or COVERAGE.

FACE 1.0

This is a plotter scaling factor used to adjust the plot size to a particular size paper. The plot is initially sized to fit on an 8 1/2 x 11 inch sheet.

Integer Parameters For SET Command and Default Values:

LAB 1

Label suppression flag. If LAB is set to 0, then satellite numbers and tags are not printed on the plot. This allows many satellites to be placed on the same plot without the labels overwriting the maps.

YEAR Current Year

Set base year for time functions.

PSYM 0

If PSYM is not equal to 0, each plotted satellite point will be labeled with the pass number of that orbit.

NSIT 27

Number of sites in the site list. As sites are defined using the SITE command, this variable is incremented. Resetting the variable allows errors to be corrected. For instance, if an error was made while entered a new site (#28), then resetting NSIT to 27 would delete the site 28 and allow the site to be redefined.

LDAY 2

Line format (see Appendix A) for daytime passes. If LDAY = 0 no daytime passes are shown by the COVERAGE command.

LECL 3

Line format (see Appendix A) for eclipse passes (satellite in the shadow of the earth).

2. TIME <DAYS<,HOURS<,MINUTES<,SECS>>>>

Set the time at which all satellite passes start. Days are Julian days from the beginning of the year. All times are GMT. The year used can be set through the SET command.

3. SAT <SAT NO.>

SAT reads a satellite element set into a common area for use of the PASS, COVERAGE, and SYNCH commands. If a satellite number is specified that satellite is used. If no satellite number is present the next satellite in the catalog is used. The current element set is displayed on the ADDS terminal.

4. OLD <SAT NO.>

OLD is identical to SAT except the old element set rather than the current set is fetched.

5. NEW <SATNO<,I, NODE, E, PERIGEE, MEAN ANOM., MEAN MO.>>

NEW allows an element set to be entered into the element common area from the ADDS terminal. The satellite tag is set to 'OPERATOR'.

6. SITE LIST

List all currently defined site names. The currently defined sites are listed in Appendix B.

7. SITE <NAME <,LAT, LONG, HEIGHT>>

List or define site locations. If SITE alone is used, the current site parameters are listed. If a name is mentioned, then the coordinates of that site are displayed. If coordinates (degrees north latitude, degrees east longitude, meters above

the geoid) are specified a new entry under 'NAME' is made in the site list. if 'NAME' is already defined then the first entry will always be the effective one. More complete list editing can be done by setting the parameter NSIT with the SET command. NSIT is the number of the last entry in the site list. A newly defined site will have number NSIT + 1, and then NSIT will be incremented.

8. ACT <SITE 1<,SITE 2<,SITE 3.....>>>

Activate sites or list active sites. An internal flag is set to activate all sites mentioned. The active status is used by the PLOT and COVERAGE commands.

If no site names are present a list of the currently active sites will be displayed

9. DEACTIVATE SITE 1<,SITE 2<,SITE 3.....>>

Deactivate the mentioned sites.

10. MAP <IPROJ, LAT, LONG>

MAP must be the first plotting command issued after the program is initialized. It initializes the plotter and certain plotting parameters, and then draws a world map. Four projections are currently available, selected by IPROJ. They are:

1. Azimuthal equidistant
2. Azimuthal equal area
3. Orthographic (normal infinity perspective)
4. Azimuthal equidistant, one hemisphere only

LAT and LONG are the latitude (north) and longitude (east) of the map tangency point (map center point). Any location on the globe can be chosen. Some choices (such as 0 for latitude) will cause some spurious plotting of coordinate lines. The projection chosen will be used for all subsequent plotting until a new map command is issued. The four projections are illustrated in Figures 1 and 2.

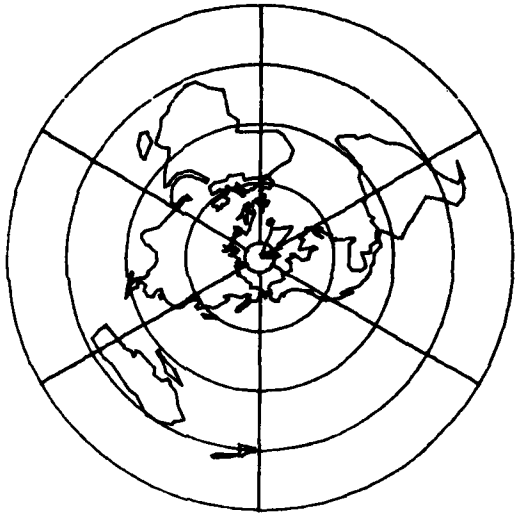
Continents are drawn on the map from a data file of approximately 500 points on the magnetic tape CONDIG2. To save time many islands and all of Antarctica are not drawn. This data base was made by digitizing a map on the same plotter used for output plotting.

11. PLOT ACT

PLOT SITE 1, SITE 2,SITE 3....

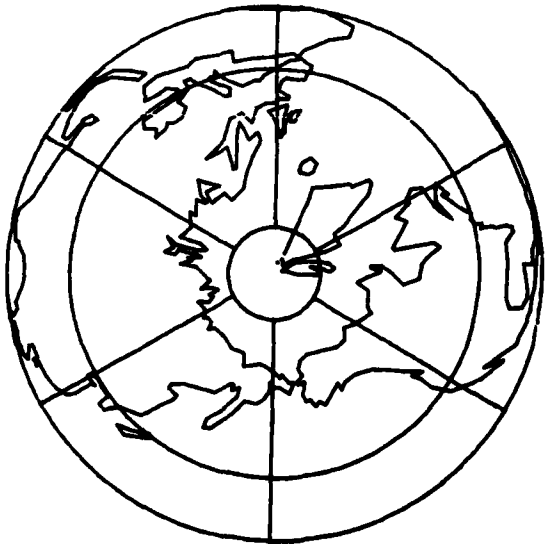
This command plots the position of sites on the map and labels each site. If 'ACT' is used as the parameter all active sites are plotted.

If HT is not equal to 0 (the default is zero, HT can be set with the SET command) then a coverage circle for constant altitude orbits for each site chosen is plotted. The altitude used is also written above the maps. The coverage circle is for the altitude HT above the GEOD (in kms) and for the horizon limit as defaulted to 20° or set by SET HOR.

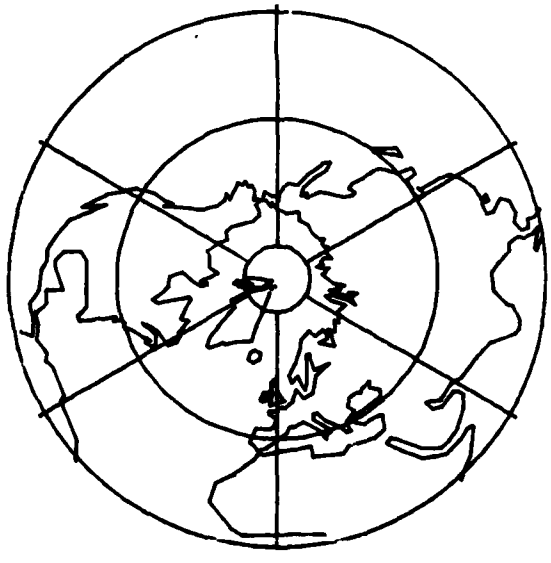


1. Equidistant

2. Equal Area



3. Orthographic



4. Equal Area(one hemisphere)

Fig. 1. Map projections with lat = 90.0, long = 0.0 as tangency point.

1. Equidistant

2. Equal Area

3. Orthographic

4. Equal Area (one hemisphere)

Fig. 2. Map projections with lat = 42.6, long = 288.5 as tangency point.

12. PASS PASS 1<,ENDPASS>

13. COVERAGE PASS 1<,ENDPASS>

Both these commands draw the ground trace of the currently chosen satellite. Any number of passes (revolutions) can be drawn. Passes are counted as orbital periods from the currently set epoch time. The passes from PASS 1 through ENDPASS will be plotted. If PASS 1 = ENDPASS (one pass only to plot), ENDPASS does not have to appear.

The satellite ephemeris is calculated at set time intervals, determined by the settable variable STEP.

If COVERAGE is being run, a line is drawn from the satellite position to all active sites which can see the satellite at that time. If the satellite is eclipsed or the site is in daylight a dashed line can be used to indicate these sighting conditions. Such dashed lines are controlled by the variable LDAY and LECL. See Appendix A for dashed line formats. If LDAY or LECL are set equal to 0 no line will be drawn.

14. POINT DAY<,HR<,MIN<,SEC>>>, TO, DAY<,HR<,MIN<,SEC>>>

POINT is identical to COVERAGE except a time interval is specified instead of pass numbers. Note that if there are no active sites PASS and COVERAGE produce the same results.

15. SYNCH <NSYM<,NPEN>>>

This command writes a special symbol at the next equator crossing of the current satellite. The pen number can also be chosen if desired.

Since a truly synchronous satellite stays over a single point on the earth, its ground trace is not easy to see on a map. This command allows a recognizable symbol to indicate a synchronous satellite's station. The symbols are defined in the HP7221A plotter manual.

If a non-synchronous satellite is chosen an error message and the satellite element set are displayed.

16. PEN N

This command selects a new pen for the HP 7221A four pen plotter. N is the pen number (modulo 5) of the pen chosen. This command has the same effect as manually choosing a pen, but the selection is in proper sequence with other plotting commands.

17. EXIT

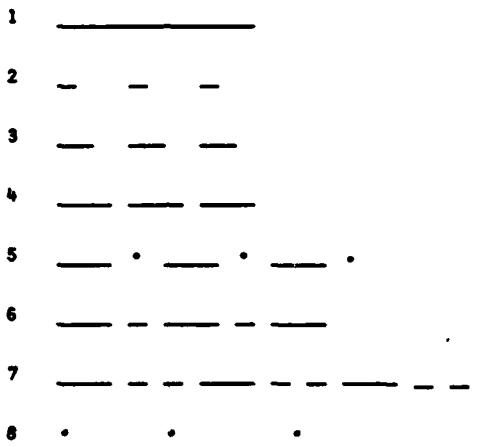
EXIT removes the program from the system and releases all resources.

V. CONCLUSION

A flexible program for plotting satellite ground traces and for determining satellite visibility from a network of ground stations has been described. The concept of such a program is not unique, and this program is a direct descendent of similar programs formulated by other groups within Lincoln Laboratory. However, the program has been adapted to a network of optical sites and fully integrated with the file structure and computer environment of the Lincoln Laboratory GEODSS system.

APPENDIX A

Line formats for HP 7221A Plotter



APPENDIX B

The currently defined sites are:

MIL: Millstone Hill, MA

HAY: Haystack Observatory, MA

ARE: Arecibo Radio Observatory, Puerto Rico

EGL: Eglin Air Force Base, FL

ETS: Lincoln Experimental Test Site, NM

SHEM: Shemya, AK

GMP: GEODSS Mid Pacific Site, HA

EDW: Edwards Air Force Base, CA

NAV: Navapasur, VA

RML: Range Measurements Lab, Patrick AFB, FL

GWP: GEODSS West Pacific Site, Korea

GME: GEODSS Middle East Site, general area

GEA: GEODSS East Atlantic Site, Morocco

DIAB: Diyarbikar, Turkey

DIEG: Diego Garcia

MTJ: Mount John, New Zealand

SANV: San Vito, Italy

CLDL: Cold Lake, Alberta, Canada

KWAJ: Kwajalein Atoll, Marshall Islands

CTIO: Cerro Tololo Observatory, Chile

NWC: Northwest Caper, Australia

SEY: Seychelles Islands

STM: St. Margarets, Canada

ISR: Negev Desert, Israel

PLES: Plesetsk, USSR

TYUR: Tyuratam, USSR

KASY: Kasputin Yar, USSR

APPENDIX C

Three examples of plots are given. The command streams used to generate the plots were:

EXAMPLE 1

```
MAP 3,33.8,253
SAT 8833
PASS 1,2
PLOT ETS
```

EXAMPLE 2

```
MAP 2,90,0
ACT ETS,GMP,GWP,SANV
SET HT 35000
PLOT ACT
SAT 8774
SYNCH 5
```

EXAMPLE 3

```
MAP 2,90,0
ACT ETS,GMP,GWP,SANV
SAT 6192
COV 1,2
PLOT ACT
```

10. 20 DAY 365, 31 DEC 78

8833. USSR 76041 A 5 MOLNIYA 3 (CF 8844)

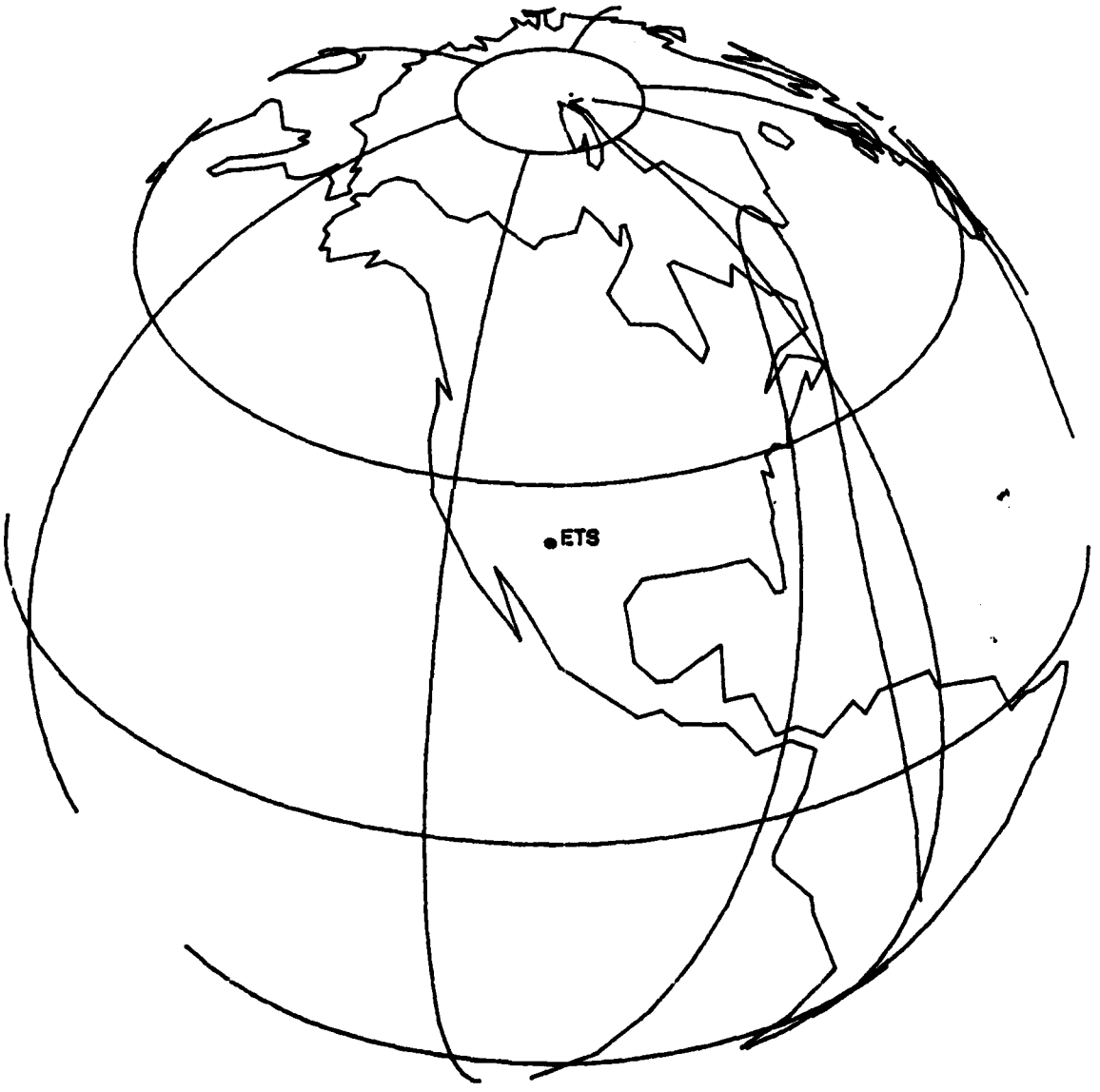


Fig. C-1. Example 1.

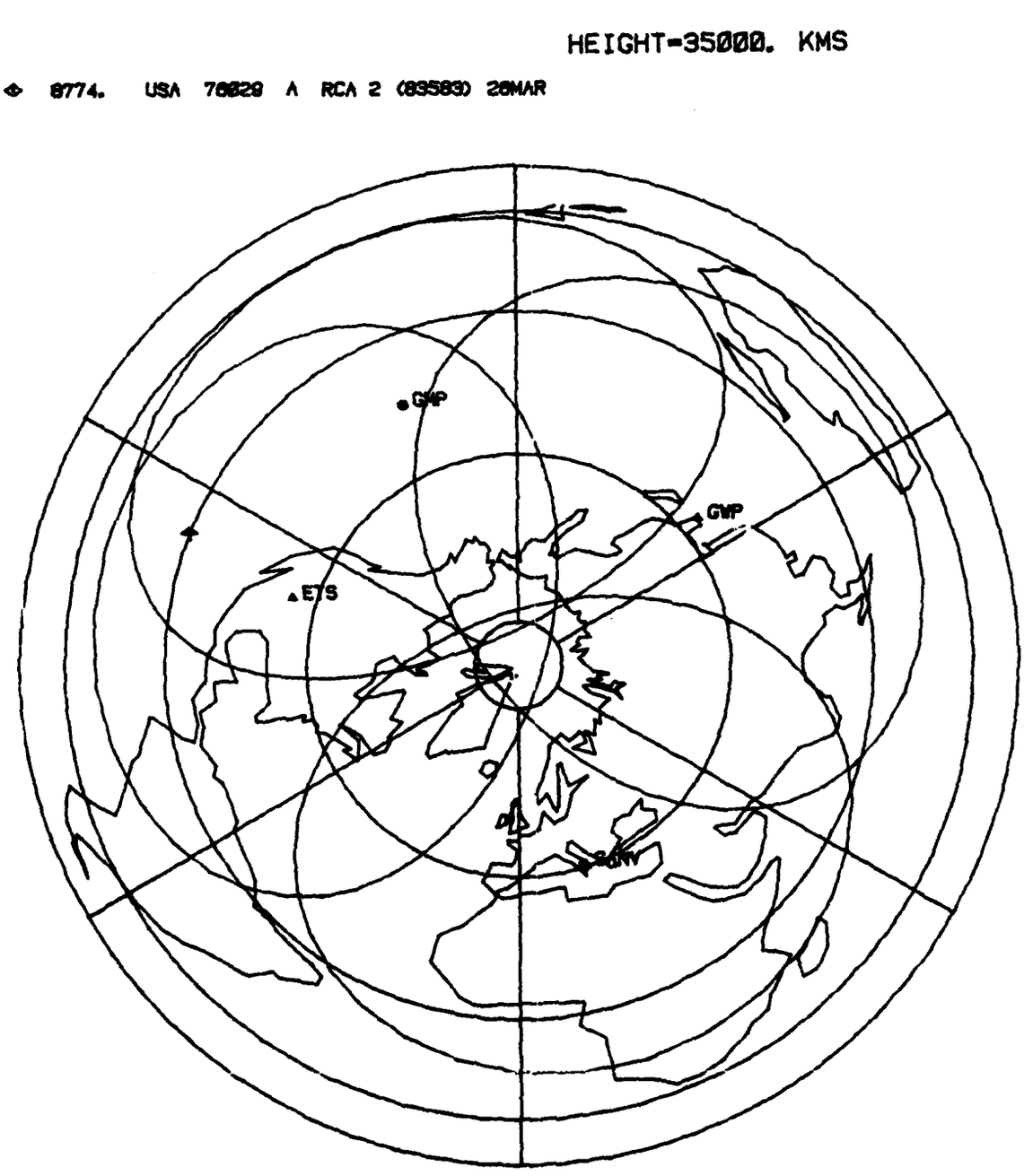


Fig. C-2. Example 2.

10: 20 DAY 365, 31 DEC 78

6192. USSR 72 72 A COSMOS 520

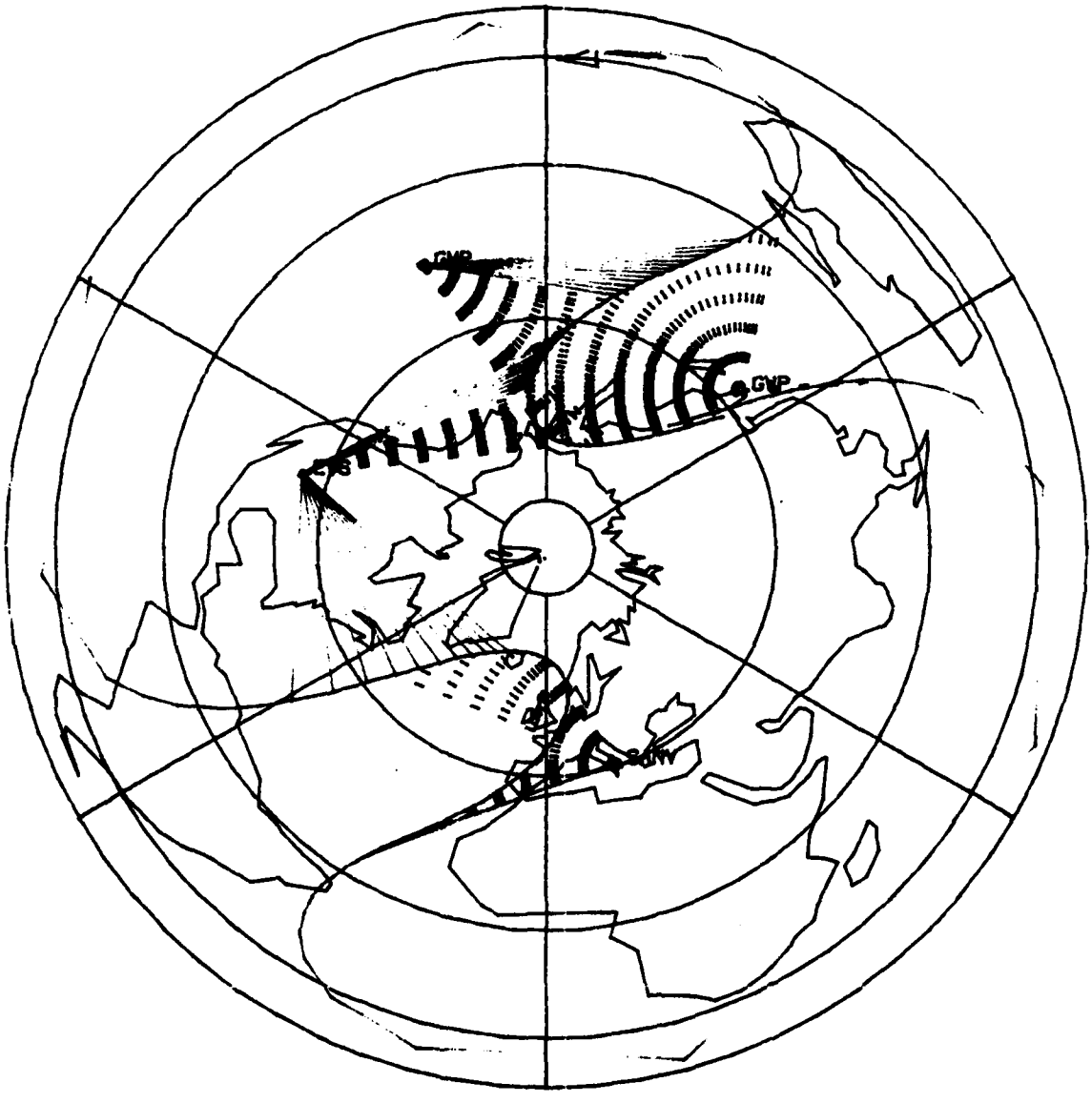


Fig. C-3. Example 3.

ACKNOWLEDGMENTS

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An interactive computer program has been developed for plotting world maps, satellite ground tracks, and orbit coverage by a system of ground sensors. All plotting is done by an HP7221A four color pen plotter attached to the Modcomp IV. This report is a users manual for this program, and contains several examples of plots.

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